Current psychology letters
Behaviour, brain & cognition

10, Vol. 1, 2003 | 2003
Special Issue on Language Disorders and Reading Acquisition

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Electronic version
URL: http://journals.openedition.org/cpl/248
ISSN: 1379-6100

Publisher
Centre PsyCLÉ

Electronic reference
Liliane Sprenger-Charolles and Willy Serniclaes, « Reliability of Phonological and Surface Subtypes in Developmental Dyslexia: A Review of Five Multiple Cases Studies », *Current psychology letters* [Online], 10, Vol. 1, 2003 | 2003, Online since 30 March 2006, connection on 15 November 2019. URL : http://journals.openedition.org/cpl/248

Reliability of Phonological and Surface Subtypes in Developmental Dyslexia: A Review of Five Multiple Cases Studies

Liliane Sprenger-Charolles and Willy Serniclaes

1 According to the dual-route model (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001), written words can be processed either by an orthographic procedure based on lexical units, or by a sublexical phonological procedure based on grapheme-phoneme correspondences. Data on acquired dyslexia have played a crucial role in the elaboration of this model, as they show that these two reading procedures can be selectively impaired, the orthographic procedure for "Surface Dyslexics" (S-DYS, Coltheart, Masterson, Byng, Prior, & Riddoch, 1983), the phonological procedure for "Phonological Dyslexics" (Ph-DYS, Beauvois & Derouesné, 1979). One important question is whether these two subtypes could be found in developmental dyslexics, that are not suffering from a deficit due to brain damage but from a problem during the development of the cognitive architecture for reading. If we assume that a single procedure – the phonological procedure – provides the basic mechanism for acquiring written word knowledge (Ehri, 1998; Share, 1995; Sprenger-Charolles, Siegel, Béchennec, & Serniclaes, 2003), a phonological deficit should necessarily lead to an orthographic deficit. Thus, dissociated profiles should not be found in developmental dyslexia. However, studies based on single cases of developmental dyslexia have shown some cases of Ph-DYS (Campbell & Butterworth, 1985; Snowling, Stackhouse, & Rack, 1986; Temple & Marshall, 1983), and of S-DYS (Hanley, Hastie, & Kay, 1992; Valdois, 1996). Because in these studies only single cases of dyslexics showing typical dissociations were selected, it is not possible to know the prevalence of these profiles as well as that of mixed profiles, which might represent a significant proportion of the dyslexic population.

2 To assess the prevalence of the different profiles, it is necessary to rely on large samples. The basic principle for classifying dyslexics is to compare their scores to those of average readers on phonological reading skills, mainly assessed with pseudoword reading, relative to orthographic skills, mainly assessed with irregular word reading. To do so, there are two methods that differ in the way the cutoffs are defined: the classical method and the regression based method. In the classical method, cutoffs are based on average readers' performance distributions on pseudoword and on irregular word reading. A dyslexic's pseudoword or irregular word error score or processing time is considered indicative of a deficiency if it is more than one standard deviation above the average-readers' mean score (or below, when accuracy scores are taken into account). Dyslexics who are impaired for pseudowords without being impaired for irregular words are labelled Ph-DYS; those who are impaired for irregular words without being impaired for pseudowords are labelled S-DYS. According to this method, the identification of subtypes is based on a selective impairment in phonological or in orthographic reading skills. Like Stanovich, Siegel and Gottardo (1997), we refer to such subtypes as "hard" cases of Ph-DYS or S-DYS, as opposed to the "soft" cases found with the regression method on the basis of the observation of a relative deficit in one skill as compared to the other. In this method, cutoffs are based on the regression lines relating pseudoword scores to irregular word scores in average readers. A dyslexic with a pseudoword score beyond the confidence interval limits of average readers when the pseudoword score is predicted from the irregular word score is classified as deficient in pseudoword reading. Alternatively, a dyslexic who exhibits an irregular word score beyond the confidence interval limits of average readers when the irregular word score is predicted from the pseudoword score is classified as deficient in irregular word reading. Dyslexics deficient in pseudowords only, or on irregular words only, are respectively labelled soft Ph-DYS or soft S-DYS.

3 These two methods were used in three studies involving English dyslexics (Castles & Coltheart, 1993; Manis, Seidenberg, Doi, McBride-Chang, & Peterson, 1996; Stanovich et al., 1997) and in two studies with French dyslexics (Génard, Mousty, Content, Alegria, Leybaert, & Morais, 1998; Sprenger-Charolles, Colé, Lacert, & Serniclaes, 2000).

Prevalence of Subtypes according to the Classical and to the Regression MethodsClassical Method

4 In the five studies, dyslexics' accuracy scores were compared to those of average readers of the same chronological age. In Sprenger-Charolles et al.'s (2000) study, time latencies for correct responses were also taken into account. The results are shown in Table 1. The percentage of both hard Ph-DYS and S-DYS profiles was low, and that of dyslexics with a double deficit was high. However, according to accuracy scores, the proportion of Ph-DYS and S-DYS was almost the same in English (Castles & Coltheart, 1993; Manis et al., 1996; Stanovich et al., 1997) while there were fewer Ph-DYS than S-DYS in French (Génard et al., 1998. Sprenger-Charolles et al., 2000). Alternatively, in French, there were a similar proportion of Ph-DYS and S-DYS according to time latencies; when both accuracy scores and processing times were taken into account, almost all the French dyslexics appeared to suffer from a double deficit (Sprenger-Charolles et al., 2000).

Table 1

Classical Method and Regression-based Method (% of the different subtypes as compared to chronological age controls)

	Castles & Coltheart (1993), E*, Age 11	Manis et al. (1996) E*, Age 12;6	Stanovich et al. (1997) E*, Age 9	Génard et al. (1998) F*, Age 10	Sprenger et al. (2000) F*, Age 10	
Classical Method						
	Accuracy	Accuracy	Accuracy	Accuracy	Accuracy	Time latency
Ph-DYS	15%	10%	9%	3%	10%	16%
S-DYS	17%	10%	12%	23%	19%	19%
Double Deficit	60%	76%	75%	67%	68%	52%
Without Deficit	8%	4%	4%	8%	3%	13%
Regression-based Method						
	Accuracy	Accuracy	Accuracy	Accuracy	Accuracy	Time latency
Ph-DYS	55%	33%	25%	4%		52%
S-DYS	30%	30%	22%	56%		32%
Double Deficit	6%	10%	28%	3%		3%
Without Deficit	9%	28%	25%	37%		13%

*E = Studies with English-speaking children, *F = Studies with French-speaking children

Regression-based Method

5 In all the studies, except one (Sprenger-Charolles et al., 2000), soft subtypes were determined according to accuracy data. In Sprenger-Charolles et al.'s study, because of ceiling effects for irregular word reading in average-readers, the regression method was used only with correct response time latencies. The scores of the dyslexics were compared to those of average readers of either the same chronological age or of the same reading level.

Chronological Age Comparison.

6 The results are shown in Table 1. In Stanovich et al.'s study (1997), an exceptional 28% of the dyslexics were impaired both in phonological and in orthographic reading skills, while in the other studies less than 10% of the dyslexics had both deficits. However, the relative proportion of soft Ph-DYS and soft S-DYS profiles strongly differed between studies. In English, according to accuracy scores, almost the same proportion of soft Ph-DYS and S-DYS profiles was observed in two studies (Manis et al., 1996; Stanovich et al., 1997), while more soft Ph-DYS than soft S-DYS profiles were found in the other study (Castles & Coltheart, 1993). In French, according to accuracy scores, there were more soft S-DYS than soft Ph-DYS profiles (Génard et al., 1998), the opposite trend being observed according to processing times (Sprenger-Charolles et al., 2000). In addition, a noticeable number of dyslexics without any deficits was found in three studies (Manis et al., 1996; Stanovich et al., 1997; Génard et al., 1998).

Reading Level Comparison

7 In the five studies, soft S-DYS profiles almost disappeared (between 0% and 5%). Alternatively, at least in four studies, the number of soft Ph-DYS profiles remained high (almost 40 % in Castles & Coltheart, 1993, and in Sprenger-Charolles et al., 2000; near 25% in Manis et al., 1996, and in Stanovich et al., 1997). Only 8% of soft Ph-DYS remained in the other study (Génard et al., 1998), in which 0% of soft S-DYS were found. Thus, the S-DYS profile seems to correspond to a simple developmental lag, insofar as

these dyslexics perform similarly to younger children of the same reading level, whereas the Ph-DYS profile seems to correspond to a deviant developmental trajectory, not observed in reading level controls.

Discrepancy between the results

8 The results observed with the regression method for the reading level comparison were fairly consistent across the five studies. Alternatively, those obtained with the same method for the chronological age comparison strongly differed from one study to the other (from 4% to 55% for the soft Ph-DYS profile, for example). These results also strongly differed from those obtained with the classical method for the same comparison. For example, according to the regression method, less than 10% of the dyslexics were found to suffer from a double deficit (except in Stanovich et al.'s study), while the classical method revealed more than 50% of the dyslexics to have a double deficit. In addition, with the regression method a significant number of dyslexics showed no deficits (more than 25% in 3 studies), which was never the case with the classical method.

Plausible explanations of the differences between the studiesEffect of the Children's Chronological Age

9 Differences in dyslexics' chronological age may account for some discrepancies among the studies using the regression method. As suggested by Stanovich et al. (1997), the large proportion of soft dyslexic profiles showing both deficits in their own study might be due to the fact that their dyslexics were younger (9 years old) than in the other two English studies (11 years old in Castles & Coltheart, 1993; 12 years old in Manis et al., 1996). Some young dyslexics "in both the deviant groups might continue to practice reading and to receive considerable exposure to print (...). This print exposure may result in these children having relatively less seriously impaired orthographic processing mechanisms (...). However, their more seriously impaired phonological processing abilities will probably not develop at the same rate (...), thus resulting in greater dissociation between phonological coding ability and exception word fluency with development" (Stanovich et al., 1997, p.124). This could cause a greater number of dissociated profiles, especially Ph-DYS, among older dyslexics than among younger ones.

10 However, in the studies of Castles & Coltheart (1993) and of Manis et al. (1996), but not in the study of Stanovich et al. (1997), the age range was broad in the dyslexic samples. More than 6 years separated the youngest dyslexics from the oldest ones, who were 15 years old. Thus, the data could conceal strong differences among the ages considered. In addition, if the explanation provided by Stanovich et al. was correct, a similar trend would be observed with the classical method. This was not the case as, first, the proportion of the different subtypes was nearly the same in the study with the older dyslexics (Manis et al., 1996) and in the study with the younger ones (Stanovich et al., 1997). Second, in the former study, the proportion of hard Ph-DYS profiles was not higher than that of hard S-DYS profiles, results expected according to the explanation provided by Stanovich et al.

Effect of the Children's Language

11 In English, according to the regression based method, the proportion of Ph-DYS was larger than in French, at least when accuracy scores were taken into account. This discrepancy may be due to linguistic differences. Since grapheme-phoneme correspondences are more consistent in French than in English (Peereman & Content,

1999), French-speaking children may be in a better position than English-speaking children to overcome the difficulties associated with the mastery of the phonological reading route. Thus, the Ph-DYS profile should be rarer in French than in English. This is the result found in studies based on accuracy data (see the hard subtypes in Génard et al., 1998 and Sprenger-Charolles et al., 2000 and the soft subtypes in the former study). However, the French study based on processing time (see the soft subtypes in Sprenger-Charolles et al., 2000) revealed almost as many Ph-DYS as the English studies only based on accuracy scores. These results suggest that most of the time the French Ph-DYS would be able to correctly map graphemes to phonemes, their phonological deficit only showing up as slow pseudoword reading. This result helps us to understand the discrepancy between the French results based on accuracy and those based on processing time.

12 The results obtained for processing time, and their explanation, are consistent with those observed with the same measure in a cross-linguistic study of English, French and Italian adult developmental dyslexics (Paulesu, Demonet, Fazio, McCrory, Chanoine, Brunswick, Cappa, Cossu, Habib, Frith, & Frith, 2001). As compared to controls, at the behavioural level, the dyslexics' phonological and orthographic impairments were more or less significant depending on the transparency of the written system; however, whatever the language, the phonological impairment appeared to be the most severe. Nevertheless, a common deficit of neural activation was found in the three groups of dyslexics, suggesting that their reading impairment was due to a similar deficit at the level of the brain.

Differences between measures

13 Given that both accuracy and processing speed characterize an efficient skill, and provided the differences previously noted between these two measures, it is crucial to examine what happens when both accuracy scores and processing time are taken into account in the same study, which was the case in Sprenger-Charolles et al.'s study (2000). The results of the dyslexics classified as soft Ph-DYS or soft S-DYS were compared to those of same age and same reading level controls on pseudoword and irregular word time latencies (the defining measures) and on accuracy scores for the same items. In the comparison with same chronological age controls, a phonological deficit in Ph-DYS relative to S-DYS and an orthographic deficit in S-DYS relative to Ph-DYS were only found on the defining measures. In addition, the Ph-DYS read pseudowords more slowly than the S-DYS and the S-DYS read irregular words more slowly than the Ph-DYS. Thus, the soft subtypes were correctly determined, at least according to time latency since no difference was found between the Ph-DYS and the S-DYS for accuracy scores. However, when comparing the results of the dyslexics to those of younger children of the same reading level, although the orthographic skills of both groups of dyslexics were not more impaired on any measure, their phonological skills appeared to be deficient either according to time latencies, for the soft Ph-DYS, or according to accuracy scores, for the soft S-DYS. These results suggest that a phonological deficit is at the core of developmental dyslexia. The fact that this deficit emerged in processing time for Ph-DYS, and in accuracy scores for S-DYS, suggests a trade-off between processing time and accuracy. The observed differences between speed and accuracy in phonological processing could be explained by the fact that the slowest dyslexics were also the most accurate ones. These children may try to

overcome their phonological disability by increasing their processing time. Inversely, the fastest ones may choose rapidity to the detriment of accuracy.

Final caveats about subtypes in developmental dyslexia

14 This review indicates that the proportion of each subtype varied according to the method, the measure, the dyslexics' language and their chronological age. Only two results appeared consistently across the five studies. First, with the classical method, and as compared to chronological age controls, most of the dyslexics appeared to suffer from a double deficit. Second, with the regression based method, and as compared to reading level controls, the S-DYS – not the Ph-DYS – almost disappeared, thus suggesting that the latter profile, not the former, corresponds to a developmental deviance. Finally, in the sole study in which both accuracy scores and processing times were taken into account, in the comparison with reading level controls, only the phonological skills of the dyslexics were found to be impaired, either in accuracy, for the S-DYS, or in processing time, for the Ph-DYS.

15 These results indicate that the phonological impairment of the dyslexics was quite severe, since it emerged even relative to younger average readers of the same reading level (see also Rack, Snowling, & Olson, 1992; and for French children, Casalis, 1995). They also indicate that a phonological impairment may lead to an orthographic impairment as, according to the classical method, in the comparison with chronological age controls, most of the dyslexics were found to suffer from a double deficit. These results are more in line with the hypothesis that a phonological deficit is at the core of developmental dyslexia (Snowling, 2001), than with Castles and Coltheart's idea that "a clear double dissociation exists between surface and phonological reading patterns" (1993, p.174).

Acknowledgments

16 The French studies presented in this paper were supported by a grant from the French ACI “Cognitique” (COG 129) of the French Ministère de la Recherche.

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ABSTRACTS

We reviewed five studies that relied on the same methodologies to determine the prevalence of Phonological, Surface and Double-Deficit-Subtypes in developmental dyslexia. The proportion of these subtypes was found to vary according to the method (classical method or regression method), the measure (accuracy or processing time), the dyslexics' language (English or French) and their chronological age. Only two results appeared consistently across the studies. First, with the classical method, and as compared to chronological age controls, most of the dyslexics appeared to suffer from a double deficit. Second, with the regression method, and as compared to reading level controls, the surface profile, though not the phonological profile, almost disappeared, thus suggesting that only the latter corresponds to a developmental deviance. In addition, in the sole study in which both accuracy and processing time were taken into account, in the comparison with reading level controls, only the phonological skills of both the phonological and the surface dyslexics were found to be impaired, either in accuracy or in processing time. These results are more in line with the hypothesis that a phonological deficit is at the core of developmental dyslexia, than with the idea that a clear dissociation exists between surface and phonological profiles.

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Keywords: developmental dyslexia, phonological dyslexia, methods used to classify dyslexics, orthographic reading Skills, phonological reading skills, surface dyslexia

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